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Guy David
Evan Rawley
Daniel Polsky

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ABSTRACT

We develop a formal model to show how integration solves task allocation problems between organizations and test the predictions of the model, using a large and rich patient-level dataset on hospital discharges to nursing homes and home health care. As predicted by the theory, we find that vertical integration allows hospitals to shift patient recovery tasks downstream to lower cost delivery systems by discharging patients earlier and in poorer health, and integration leads to greater post-hospitalization service intensity. While integration facilitates a shift in the allocation of tasks, health outcomes are no worse when patients receive care from an integrated provider. The evidence suggests that by improving the allocation of tasks, integration solves coordination problems that arise in market exchange.

Guy David
The Wharton School
University of Pennsylvania
202 Colonial Penn Center
3641 Locust Walk
Philadelphia, PA 19104-6218
and NBER
gdavid2@wharton.upenn.edu

Evan Rawley
The Wharton School
University of Pennsylvania
2000 Steinberg Hall-Dietrich Hall
3620 Locust Walk
Philadelphia, PA
19104-6370
rawley@wharton.upenn.edu

Daniel Polsky
University of Pennsylvania School of Medicine
Division of General Internal Medicine
423 Guardian Drive, Blockley Hall, Rm 1212
Philadelphia, PA 19104
polsky@mail.med.upenn.edu

1. Introduction

This paper examines how integration solves task allocation problems between organizations. In particular, we focus on timing problems in market exchange that arise from the misallocation of tasks between two vertically distinct stages of production. Since the seminal work of Masten, Meehan and Snyder (1991) scholars have made great progress toward understanding how timing problems in market exchange influence vertical integration. For example, Nickerson and Silverman (2003) demonstrate that trucking firms vertically integrate in the less-than-truckload (LTL) segment to avoid disruption of closely coordinated breakbulk operations, and Forbes and Lederman (2009) show how the risk of cascading delays lead major airlines to own regional carriers that operate routes originating or terminating at the majors' hubs (or other cities that are important to the majors' network). We build on the idea that the timing of exchange influences transactional efficiency, and thereby vertical integration, but instead of studying timing as a "ripple effect" problem (Nickerson and Silverman 2003, p.438) with "system-wide effects" (Masten, Meehan and Synder 1991, p.8) that cascade through "network-based industries" (Forbes and Lederman 2009, p.1833), we focus instead on timing problems as task allocation problems that may arise under general conditions of bilateral market exchange.

We formalize the intuition behind the idea that the misallocation of tasks across sites of production has performance implications, testing the predictions of the model in the context of the patient care continuum, where patients transition from acute care facilities (hospitals) into post-acute care (nursing homes and home health). The empirical application demonstrates the role of task allocation in influencing the efficiency of transactions and firm boundary decisions. Taking the sequence of clinical interventions (or tasks) along the care continuum as fixed—patients need a well-defined set of clinical interventions to address their health care needs—exchange is, therefore, characterized solely by the timing of transitions across settings. Systematic variation in cost structures and reimbursement rates between hospitals and post-acute care providers coupled with regulatory restrictions on side-payments (which represent a strong form of contractual incompleteness) ensures that tasks will not be efficiently assigned unless the hospital and downstream providers are vertically integrated.[1] However, integration costs are non-trivial such that there is substantial heterogeneity in governance regimes: about a third of nursing homes and home health agencies are vertically integrated into hospitals.

One major advantage of our empirical design is that we can track patients across organizations, which allows us to pinpoint how integration influences tasks on both sides of the exchange relationship. The ability to observe the clinical procedures patients receive in post-acute care at a high-level of detail is particularly important to our empirical assessment of patient health at the time of discharge. The evidence shows that, on average, vertical integration leads to shorter hospital stays for six out of every ten patients who are discharged to a skilled nursing facility or home health agency. We also find that patients received higher intensity of care from vertically integrated home health providers. The results support the central thesis of the paper: integration solves task allocation problems. Notably, while we find striking differences in the organization of services across sites, vertical integration does not lead to a decline in patient health outcomes, suggesting that different allocations of tasks across assets (or sites) produces similar (or higher) levels of care quality.[2]

The contributions of this research are twofold. First, we develop a tractable model of integration and task allocation that extends the conceptual basis for vertical integration as a solution to inter-firm coordination problems in the presence of incomplete contracts. Second, we demonstrate empirically how integration changes the allocation of tasks to assets and, thereby, mitigates inefficiencies in market exchange that arise even in the absence of cascading organizational problems typically described in the literature on timing and vertical integration (Masten, Mehan and Snyder 1991; Pirrong 1993; Nickerson and Silverman 2003; Forbes and Lederman 2009, 2010).

2. Theory and related literature

In this section, we describe and then formalize the intuition for task misallocation as a basis for vertical integration. We show that when counterparties' objectives conflict with respect to a focal task and contracts are incomplete (i.e., due to regulation of side-payments, as in our application), market exchange will likely fail to generate the optimal allocation of tasks. In such cases, vertical restraints will not yield the efficient level achieved through vertical integration, and even though hierarchical governance leads to bureaucratic costs under integration, the misallocation of tasks under market exchange can generate costs that would justify integration.

By examining the relationship between vertical integration and task allocation we build on an emerging literature that links vertical integration to adaptation and performance. For example, Novak and Stern (2008) show how vertical integration allows automobile manufactures to adapt to unforeseen contingencies, and Forbes and Lederman (2010) demonstrate that vertical integration facilities real-time adaptation decisions between major airlines and their regional partners. This research also analyzes how vertical integration influences the coordination of production activities within and between firms in the context of incomplete contracts, though we put some additional structure on the problem by formalizing the relationship between vertical integration and performance in an equilibrium model that emphasizes the tradeoff between optimal task allocation and bureaucratic costs.

This research is also closely related to the literature on temporal specificity, which locates the source of contracting problems in the timely production or delivery of goods or services, where temporal specificity refers to the value lost when an open market transaction is not performed in a timely manner, compared to the value of the same transaction when performed within an integrated firm (Masten, Meehan and Snyder 1991).[3]

As is standard in the temporal specificity literature, we assume that production takes a sequential form in which a sequence of tasks leads to production of an output. For example, Pirrong (1993) studies timing problems in the context of the bulk shipping market where shipping must follow production and precede sales in a pre-determined sequence, and contracting over the timing of shipments can lead to inefficiencies because capacity "spoils" if it is not filled when a ship leaves the harbor. Similarly, in our context, given a technologically determined sequence of production, beginning with a clinical intervention (e.g. surgery) followed by patient monitoring and recovery, and ending with nursing services to ensure full recovery or management of a chronic illness, we examine how the boundaries of firms along the patient care continuum vary in the response to task allocation problems.

We extend the literature on timing problems in market exchange by highlighting the role of task allocation in influencing firm boundaries. While acknowledging the fundamental insight in the extant literature that temporal considerations can create coordination problems that influence the efficiency of exchange, we focus on the less well understand implication of the impact of task misallocation on transactional performance. Our approach endogenizes the timing of exchange by analyzing how the partitioning of the sequence of tasks across organizations (or sites) influences production efficiencies. Thus, we propose that an important class of timing problems need not necessarily arise from cascading effects that cause externalities on the rest of the organization through ripple effects inside firms within network industries, as is well documented in the literature, but can also be due to fundamental differences between firms over the optimal allocation of production tasks to assets (or sites), which can lead to inefficiencies in market-based exchange.

We analyze the allocation of tasks to sites of production in the case of a two-way vertical exchange relationship, using a framework where contracts are inherently incomplete. As is standard in the literature, we define integration as the joining of assets under unified management (Klein, Crawford and Alchian 1978; Williamson 2010). Transactions are characterized by exchanges between assets (or sites), and tasks are production activities used in conjunction with assets to produce outputs for exchange, where, for tractability, the sequence of tasks needed to achieve an outcome is assumed to be technologically pre-determined. As is common in the theory of the firm literature, we assume that integration results in increased bureaucratic costs, arising from the management of different lines of business. We do not, however, impose exogenous costs of market exchange. Instead, by distinguishing between two types of tasks—general and site-dedicated tasks—we express the cost of market exchange through the misallocation of tasks to sites. In the case of vertical integration, the allocation is internal to the firm, while in the case of market exchange, the allocation is the solution to a bilateral bargaining process. Note that if all tasks are performed in conjunction with a particular site, tasks and assets are redundant constructs and task allocation has no substantive meaning beyond the standard incomplete contracting models of vertical integration. In our framework, however, when some tasks are not site-specific, misallocation of such tasks across sites forms the basis for the cost of market exchange.

From these foundations, we propose a model where the allocation of tasks to sites shapes firm boundaries by influencing production costs. Following the discussion above, we divide tasks into two groups: tasks dedicated to a particular site and tasks that can be performed at multiple sites. The first class of tasks—*site-dedicated tasks*—represent the focal source of hierarchical governance costs, as the management of heterogeneous site-task pairs within a single firm requires costly managerial oversight (Schoar 2002). In our model, site-dedicated tasks are always allocated efficiently, as these tasks never cross the boundaries of their corresponding sites. Our second class of tasks, *general tasks*, are of particular interest, as they may span sites—that is, in an exchange relationship between two sites, both sites are technologically capable of performing the general tasks—and, therefore, may be allocated to sites differently under integration versus market exchange. Thus, in the presence of incomplete contracts, vertical integration represents a tradeoff between incurring administrative inefficiencies from governing additional heterogeneous site-specific tasks against the production benefits of allocating general tasks optimally to sites. In our application, a major clinical intervention, such as surgery, is a hospital-dedicated task, while assistance with daily activities is a home health-dedicated task. Patient recovery, on the other hand, is an example of a general task, as it is likely to span both acute care and post-acute care settings (see Figure 1).

The misallocation of general tasks is the primary source of transaction costs in our model, as non-cooperative equilibria under market exchange may lead to a distortion in the allocation of these tasks across sites. Ultimately, we show how the misallocation of general tasks across sites under market exchange can be solved through integration.

The tension between the bureaucratic costs of integration and the cost of inefficiencies associated with market exchange leads to two alternative second best solutions to the problem of exchange that rely on the concept of contract incompleteness. A first best solution can be achieved if firms maximize joined surplus, and contract to share the additional surplus from cooperatively choosing the corresponding allocation of general tasks. However, when contracts are incomplete, tasks will not be assigned to maximize joint surplus, and therefore market exchange is likely to distort the efficient allocation of general tasks. Put differently, there is no force driving firms to allocate general tasks in a way that internalizes the externality imposed on their exchange partners. By contrast, integration allows the firm to correct production inefficiencies associated with market exchange by shifting general tasks either downstream or upstream. Nevertheless, integration dampens incentives and creates bureaucracy costs that are avoided under market exchange. Thus, while our theory is consistent with transaction cost economics models, which highlight the tension between transaction costs and hierarchical governance costs (Williamson 1985), we explicitly model transaction costs in terms of production inefficiencies associated with task misallocation.

We begin with the simpler benchmark case where all tasks are site-dedicated and, hence, assets fully partition the task space. For simplicity, we normalize transaction costs from other potential sources to be zero. Assume two tasks: *i* and *j*, with corresponding assets (or sites) values, A_i and A_j, where *i* and *j* are a mapping from the specific tasks to the value of their corresponding assets. Task *i* is dedicated to the asset A_i, whereas task *j* is dedicated to the asset A_j. In addition, tasks are fixed technologically; therefore, the value of the two assets is fixed. Note that *i* and *j* do not cross the boundaries of their corresponding assets (sites), and when these are held by different firms, *i* and *j* do not cross the boundaries of their corresponding firms. Assets can contribute differently to production and therefore can generate different payoffs to the firm that owns them. Each asset, *A*, generates a payoff $\pi(A)$, which is increasing in the value of the asset, while the marginal payoff is decreasing in the value of the asset, i.e. $\frac{\partial \pi(A)}{\partial A} > 0, \frac{\partial^2 \pi(A)}{\partial A^2} < 0.$

The payoff to vertical integration is characterized by: $\pi(A_i) + \pi(A_j) - p_{ij}$, where p_{ij} is a fixed penalty that depends on characteristics of the two tasks *i* and *j*. When integrating *i* and *j* is costless (i.e. $p_{ij} = 0$), both transactions across firms and transaction within firms produce the first best efficient solution. However, when there are no transaction costs, all tasks are site-dedicated, and $p_{ij} > 0$, vertical integration will not take place in equilibrium.

When relaxing the assumption that all tasks are site-dedicated by considering general tasks, vertical integration may constitute a superior way to organize transactions. To see this, we introduce a third task, *k*, which is a general one (i.e. can be performed by either assets or sites). We further assume that a certain predetermined level of *k* is needed for technological reasons and can be split across the two assets, A_i and A_j, such that: $k = k_i + k_j$.[4] In our application, k_i represents the fraction of recovery and monitoring tasks that take place in the hospital, while k_j represents the fraction of recovery that takes place in a nursing home or by home health personnel.

The allocation of general tasks across sites that maximizes joint surplus is likely to be distorted when counterparties' profits are affected in similar ways by the focal general task. The importance of the general task, *k*, and the way it is partitioned across sites, endogenously determines the timing of exchange. The larger k is, the greater the cost of misallocating it across sites. For example, when clinical interventions result in lengthy recovery, there is greater potential for costly misallocation of recovery across sites. Contractual incompleteness impairs arrangements (e.g. side payments) that would otherwise lead to an assignment of k that maximizes total surplus. For example, in our empirical application, regulation explicitly rules out the sharing of surplus across firms and leads firms to make decisions that may impose an externality on their exchange partner (Robinson 1996), where the source of externality is the different preferences that acute care and post-acute care entities have regarding the timing of patient discharge (transition between sites of care). The timing externality is only internalized through vertical integration.

Since firms on both sides of the exchange must perform a certain predetermined level of k in order to produce output, yet cannot share the benefits from maximizing total surplus, the partition of, k into k_i and k_j is the result of a bargaining process. Following the static axiomatic theory of bargaining, we assume that the market allocation of k results in a Pareto optimal symmetric Nash bargaining solution (Nash 1953; Binmore, Rubinstein and Wolinsky 1986). Interestingly, since k is fixed (i.e. there is a fixed level of k that must be carried out for the payoff to be positive), the bargaining process involves two unique elements: first, the firms' threat points equal zero and second, bargaining exists even if the sum of both firms' proposals is less than k (i.e. firms bargain over k even if k is undesirable). This is likely the case in our application, as neither hospitals nor home health agencies are paid for the recovery task, and while patients must recover, each entity would prefer to do as little recovery as possible.

Assume firm i owns asset A_i and firm j owns asset A_j. Denote the firms' proposed level of k as $(\bar{k}_i, \bar{k}_j)$ and the Nash bargaining solution as $(\tilde{k}_i, \tilde{k}_j)$. In the simplest case, firms are symmetric and, therefore, desire the same level of k. In one extreme, k is equally undesirable (i.e. $(\bar{k}_i, \bar{k}_j) = (0,0)$), while in the other, k is equally desired by both firms (i.e. $(\bar{k}_i, \bar{k}_j) = (k,k)$). The Nash bargaining solution, in both these cases, is $(\tilde{k}_i, \tilde{k}_j) = (\frac{k}{2}, \frac{k}{2})$.

More generally, the solution to the Nash bargaining problem corresponds to $\widetilde{k}_i$ that maximizes the Nash product $\left|\widetilde{k}_i - \overline{k}_i\right| \cdot \left|(k - \widetilde{k}_i) - \overline{k}_j\right|$, in this case, a product of utilities described as the distance between the Nash bargaining solution and the desired amounts of *k*. The general solution is given by: $\widetilde{k}_i = \overline{k}_i - \frac{(\overline{k}_i + \overline{k}_j) - k}{2}$ and $\widetilde{k}_j = \overline{k}_j - \frac{(\overline{k}_i + \overline{k}_j) - k}{2}$.

It is easy to see that when $\overline{k}_i = \overline{k}_j$, the symmetric Nash bargaining solution $(\widetilde{k}_i, \widetilde{k}_j) = (\frac{k}{2}, \frac{k}{2})$ is achieved. Under the model's assumptions, there is a single efficient combination (exchange point) that maximizes the joint profits across firms, such that $\pi(A_i(k_i^*)) + \pi(A_j(k_j^*)) > \pi(A_i(k_i)) + \pi(A_j(k_j))$ for all $(k_i, k_j) \in k$, and, in particular when $(k_i, k_j) = (\widetilde{k}_i, \widetilde{k}_j)$, such that: $\pi(A_i(k_i^*)) + \pi(A_j(k_j^*)) > \pi(A_i(\widetilde{k}_i)) + \pi(A_j(\widetilde{k}_j))$. (See Figure 1 for a graphical illustration). The pair (k_i^*, k_j^*), chosen by the integrated firm, is not the result of market exchange.

Market exchange is characterized by the following sum of payoffs to firms: $\pi(A_i) + \pi(A_j)$. While vertical integration is characterized by: $\pi(A_i) + \pi(A_j) - p_{ij}$. Hence firms, in our model, will decide to vertically integrate when:

$$(1) \qquad \pi_{VI} = \pi(A_i(k_i^*)) + \pi(A_j(k_j^*)) - p_{ij} > \pi(A_i(\widetilde{k}_i)) + \pi(A_j(\widetilde{k}_j)) = \pi_{ME}.$$

This decision depends on the composition of *i*, *j*, and *k*. In particular, the greater *k* is and the smaller p_{ij} is, the more likely it is that the firms would vertically integrate (see Figure 2). Note, that since both market exchange and vertical integration involve cost, the first best payoff $\pi(A_i(k_i^*)) + \pi(A_j(k_j^*))$ is not attainable.

Economies and diseconomies of scope that stem from the interaction between site-dedicated and general tasks are also crucial for the allocation of general tasks across sites. When site-dedicated and general tasks are complements (i.e. an increase in the fraction of the task allocated to a site raises the marginal value of the other site-dedicated task), firms would benefit from concentrating general tasks in sites to maximize payoffs. In this case, the integrated firm would maximize total surplus by performing the entire general task at the site that provides it with the greatest return. In our application, given differential prospective reimbursement for acute care and post-acute care entities, hospitals stand to gain more from an early patient discharge compared to what home health agencies stand to lose from such early transition across sites of care. Therefore, vertical integration will likely result in faster transitions between the acute and post-acute settings. On the other hand, when firms make decisions in isolation and contracts are incomplete (i.e., there are frictions in the process by which firms share the surplus from cooperation), bargaining over k will lead both firms to inefficiently perform non-zero amounts of k. In Appendix A we show that task misallocation influences the cost of market exchange, by creating production inefficiencies, when there are economies of scope as well as diseconomies of scope.

Given contractual incompleteness and divergent preferences over the allocation of general tasks to sites, integration will sometimes be superior to market exchange even in the presence of positive bureaucratic costs of joint ownership, p_{ij}. Thus, our model advances the idea that vertical integration and the allocation of (general) tasks to sites is jointly determined, which has a number of testable implications. In particular, when compensating a firm for the cost associated with performing the optimal amount of a general task in the form of side-payments is not allowed, as in our empirical application, vertical integration will lead to a shift in the allocation of general tasks, such that the low-cost site performs the bulk (or all) of the undesirable general task.

We believe our model is the first to explicitly consider the role of task allocation in creating frictions in market exchange, but, of course, the model is not completely novel. Broadly, our approach follows in the spirit of Grossman and Hart (1986) and Hart and Moore (1990), hereafter GHM, in that the owners of the upstream and the downstream assets/sites have the residual rights to control all aspects of production, in particular, the timing of exchange, which cannot be explicitly given away by contract. As in GHM, we assume that contracts are inherently incomplete due to exogenous factors (e.g., regulatory restrictions), which preclude efficient rent sharing and open the door for efficient outcomes to be achieved through integration. However, while their work focuses on vertical integration as a solution to *ex ante* noncontractible investments, which are *ex post* contractible, we focus on misallocation of tasks that occur even when the state of the world is realized.

Our model is also similar to Corts's (2006) formal analysis of the allocation of tasks to assets in some important respects. In Corts's (2006) model a single asset (a truck) and a potentially delegable task (maintenance) is allocated between a principal (a firm) and an agent (a driver). When the principal delegates the maintenance task downstream, efficiency dictates asset ownership by the agent, which in turn results in greater effort in performing the delegated task. As in his model, we also link task allocation and asset ownership, but in Corts's (2006) model principal asset ownership hinders the delegation of tasks to the agent. In contrast, our analysis relies on the notion that asset (or site) ownership facilitates task delegation to achieve an efficient allocation of tasks.

It is important to note that contractual incompleteness and the existence of general tasks are not sufficient to produce inefficiencies in market exchange. There also must be a divergence in the preferences of firms regarding how general tasks are to be divided among them. If both firms strictly preferred the optimal allocation of general tasks, market exchange would achieve the first best solution. As a case in point, consider the hospice industry, which provides palliative care for terminally ill patients. Unlike the case of home health or nursing home care, candidates for hospice care are dying, not recovering. Therefore, delaying discharge to hospice means that patients transition when they are sicker. Moreover, hospice providers are paid per day and, therefore, benefit economically from getting patients earlier when their condition can be more easily managed. In this example both hospitals and hospices benefit from an early transition. The lack of conflict suggests a diminished role for vertical integration. Consistent with the idea that preferences over the timing of exchange drive vertical integration decisions we observe that while 31% of home health agencies and 36% of skilled nursing facilities are vertically integrated to hospitals, only 17% of hospices are owned and operated by hospitals (Hospice Association of America, Hospice Facts & Statistics; March 2008).

3. Empirical context: Patient transitions from hospitals to post-acute-care settings

In order to focus our predictions, we map the theoretical constructs developed in section 2 (above) to our empirical setting. Broadly speaking, we test the predictions of the model by comparing practice patterns between vertically integrated (i.e., hospitals with home health agencies and hospitals with skilled nursing facilities) and non-integrated providers along the care-continuum from acute to post-acute care settings. Health care organizations on both sides of the hospital to post-acute care exchange have divergent preferences regarding the partition of the general task; because both hospitals and home health agencies are paid prospectively, each entity would like the other to oversee patient recovery. Hospitals gain from early patient discharge while home health agencies gain from admitting patients later in the process. Since, on the margin, recovery under post-acute care is less costly, hospitals would be willing to pay post-acute care entities to accept patients sooner, but side-payments are illegal in health care (due to fear that referrals will be governed by financial interest, as opposed to clinical considerations). Therefore, inefficiency with regard to the timing of discharge arises under market exchange and is resolved under integration.

The empirical context is particularly appealing for a number of reasons. First, the health care industry of considerable size: in 2007, national expenditures were $190 billion in nursing homes and home health care and $696 billion in hospitals. Second, contracts are inherently incomplete between hospitals and post-acute care providers because they are subject to fixed prices set by Medicare with strict prohibitions on side payments between non-vertically integrated hospitals and post-acute providers. Fixed price exchange gives rise to incomplete contracting because the counterparties cannot use price to adjust for supply and demand imbalances in bilateral exchange. Limitations on side payments make it difficult for relational contracts to remedy the rigidities of fixed price exchange. Third, there is substantial cross-sectional variation in vertical integration into both skilled nursing facilities and home health across hospitals, which suggests that the costs and benefits of integration vary meaningfully across organizations in our setting. Fourth, there are clear cut site-dedicated and general tasks in this setting, and the timing of exchange influences the efficiency of care in a direct and important way. Hospitals perform specialized hospital-dedicated acute care tasks, such as surgery, but once patients are stabilized, post-operative care rapidly becomes a task that need not necessarily be bundled with the physical infrastructure of a hospital (i.e. post-operative care becomes a general task once the patient is stabilized).[5] Home health agencies and skilled nursing facilities also deliver site-dedicated and general tasks, providing care services that are only performed in patients' homes[6] or in a skilled nursing facility,[7] and assisting recuperating patients in a manner that is customized to their living environment, but also by offering a range of services that could be provided in a hospital setting, particularly monitoring, therapy, and recovery services. These general tasks are produced at much higher cost in a hospital setting compared with a post-acute setting (Candrilli and Mauskopf 2006, MetLife 2009), which, when coupled with incomplete contracts, creates coordination costs from task misallocation and the impetus for vertical integration. On the other hand, hospital integration with skilled nursing facilities and/or home health providers creates bureaucratic oversight costs for the integrated entity. Fifth, the health services industry is a collection of hundreds of distinct local markets producing roughly homogenous outputs. We exploit variation in local market conditions in our empirical design to overcome the effect of selection on unobservables to identify the impact of vertical integration on health outcomes; yet, the homogenous nature of outputs across markets facilitates an accurate comparison of the effects of vertical integration on hospitals across markets. Finally, we have access to a large and novel dataset on hundreds of thousands of patients' medical history records that tracks their care across facilities, allowing us to measure the impact of vertical integration on the allocation of tasks to sites at an unusual level of detail.[8]

Medicare reimburses care delivered by home health agencies and skilled nursing facilities through a Prospective Payment System (PPS). Under PPS for home care, a fixed reimbursement is given for a 60-day episode independent of the number of visits during the episode. Reimbursement is fixed and prospective. The amount of reimbursement is set at admission, and while it is indexed to the severity of the patient's condition the reimbursement rate is a purely administrative price, which may not be directly related to the cost of managing the patient, and is not altered based on the intensity of care delivered.[9] In the case of skilled nursing facilities, reimbursement is given for each day of stay (up to 100 days) independent of the intensity of care while at the facility. Each episode payment is adjusted for differences in labor costs across geographic areas. Within this reimbursement strategy, skilled nursing facilities and home health agencies are free to provide the intensity of care that they deem appropriate for their patient. In general, the amount of service provided does not change the amount of reimbursement, which strengthens the foundation for our assumption that contracts are incomplete in our empirical context.[10]

Hospitals are also reimbursed through a prospective payment system, often referred to as the Inpatient Prospective Payment System (IPPS). Under the IPPS, each hospital admission is categorized into a diagnostic-related group (DRG) which has a payment weight assigned to it based on the expected relative intensity of resources used to treat Medicare patients under that DRG. Rare and unusually costly cases get an increased payment, but despite this, there is no incentive for hospitals to keep their patients longer than medically necessary. Indeed, hospitals focus intensely on managing inpatient costs conditional on physicians' medical opinions about the ability of the patient to recover outside of the hospital setting through the discharge planning process.

Discharge planning is a professional process that customizes a unique plan for moving a patient from one level of care to another (Collier and Harrington, 2005). The American Medical Association and the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) offer recommendations for discharge planning, however, their recommendations are not binding and there is heterogeneity in the discharge process across hospitals (Chiplin, 2005; Moore et al., 2007). While only physicians can authorize a patient discharge, the actual process of discharge planning is handled by social workers, nurses, case managers, and discharge planners (Naylor et al., 1994). These hospital agents communicate with their counterparts at post-acute care entities to facilitate patient transitions on case-by-case basis.

The interaction between hospital and post-acute care provider over the discharge process can be characterized as a bargaining game, where bargaining over the timing of exchange yields inefficiencies in the sense that the parties will not maximize joint surplus.[11] Post-acute care providers are not required to accept a patient, and in general, have an incentive to convince the hospital that they should discharge the patient to them at a later date. Of course, in practice, there is some give and take in the negotiating process—not every patient is haggled over—and market power undeniably influences the outcomes of the bargaining game. But, the fundamental implication of market exchange is clear even in an elemental bargaining relationship, like the one we model: on the margin non-integrated post-acute care providers can delay the discharge process.

Given that the key assumptions of the model are met in the exchange relationships between hospitals and post-acute care providers—contracts are incomplete and general tasks may be performed at either hospital or post-acute care sites—the predictions of the model apply immediately to the empirical context. In particular, we examine whether hospitals that are vertically integrated discharge their patients to skilled nursing facilities and home health agencies sooner and when the patients are in poorer health compared to non-integrated hospitals.

The two predictions arise directly from the idea that vertical integration allows hospitals to allocate general tasks (i.e., recovery tasks) to their own skilled nursing facility and home health agency in a manner that is more efficient than under market exchange, subject to a bureaucratic cost penalty for integrating acute and post-acute organizations. Taking the integration penalty to be positive—the integrated entities are qualitatively dissimilar—but of a magnitude that varies by upstream firm-downstream firm pair based on exogenous factors such as the availability of land near the hospital for building a skilled nursing facility (it is generally easier to manage a post-acute care facility when it is close to the hospital), the relatedness of post-acute care provision to the hospital's portfolio of services (unrelated services are typically thought to be more expensive to provide), or the extent to which post-acute care provision is considered to be central to the hospital's mission (which changes the willingness of the hospital to incur an integration cost), we can infer the nature of the benefits of vertical integration by studying the behavior of efficiency maximizing hospitals. The model predicts that vertically integrated firms will solve the task allocation problem by shifting the general task to the low-cost provider sooner, here the skilled nursing facility or home health agency. Thus, it follows that vertically integrated hospitals will allocate recovery tasks to the downstream firm by shifting patients sooner in the recovery process and when they are in worse health.[12] Since we have assumed throughout that post-acute care providers will respond to early transitions by increasing the intensity of care downstream, we also subject the model to a further test by stating this premise as a hypothesis: on average, the quality of care patients receive should not be affected by the timing of the transition. Therefore, the three predictions of the model that we test in our context are:

> *Hypothesis 1: Vertically integrated hospitals will transition patients to skilled nursing facilities and home health agencies faster than non-integrated hospitals.*

> *Hypothesis 2: Vertically integrated hospitals will transition patients to their own home health agencies when the patients are in need of more intensive monitoring and recovery services.*[13]

Hypothesis 3: Overall quality of care need not be lower for patients transitioning faster and in worse health within vertically integrated hospitals compared to market-based transitions.

4. Data and samples

Having shown how our model of task allocation applies, in the context of patient care, we now turn to the empirical analysis. Our core data come from the Medicare Provider and Analysis Review (MEDPAR) Files for 2005. The MEDPAR is a research file compiled by the Center for Medicare and Medicaid Services, based on the billing claims of facility stays for fee-for-service Medicare beneficiaries. Each MEDPAR record represents a facility stay including acute-care-hospital stays and skilled nursing facility stays. It summarizes services provided to a beneficiary from time of admission to a facility through discharge. Each record includes: date of admission and discharge; codes for up to 5 procedures and 10 diagnoses (DRG); socioeconomic information; the patient's home zip code; and a unique identification number that is specific to a beneficiary and the hospital. This is a near-complete record of health care facility encounters for Americans over 65.[14]

To identify and characterize post-acute care home health care episodes that follow hospitalizations, we link the MEDPAR file acute-care-hospital stays to the Medicare claims for skilled nursing facilities and home health services by the scrambled identifier of the Medicare beneficiary. Home health services are recorded on the Medicare Home Health Agency Standard Analytical Files. We identify admissions to skilled nursing facilities and home health care agencies as those occurring within 3 days of the hospital discharge. Because all qualifying skilled nursing facility and home health care episodes of Medicare beneficiaries are paid by Medicare, these claims files are a complete record of home health use for the beneficiaries with MEDPAR hospitalizations. We also capture data on home health care services provided, including number of home health visits, the dates and types of visits as well as unique home health agency identifiers.

We augment the claims data with survey data on hospital organization from the American Hospital Association (2005) and with data from regulatory reports: for hospitals from the 2005 Hospital Cost Reports and for skilled nursing facilities and home health agencies from the 2005 Provider of Service Files. We use these three sources of data to determine whether hospitals are vertically integrated into skilled nursing facilities and into home health. We conservatively code hospitals as being vertically integrated when all three sources agree, though our results are robust to other criteria.

Our analysis focuses on MEDPAR hospitalizations for new health events that resulted in post-acute care admissions either directly into skilled nursing facilities or into home health. We exclude hospitalizations of existing health events from our sample, MEDPAR hospitalizations that were preceded in the 90 days prior to admission by a hospitalization or by post-acute care with a home health agency or in a skilled nursing or rehabilitation facility (though the results are not sensitive to this exclusion).[15] We then eliminate all hospitals with indeterminate vertical integration status (20% of the sample), leaving us with 399,616 discharges to home health and 460,761 discharges to skilled nursing facilities from 2,571 hospitals.[16]

Table1-A shows summary statistics for patients, hospitals and markets (counties) for discharges to home health. Columns (1) and (2) show the means and the standard deviations for the full sample. Medicare patients are elderly, the average age is 78, primarily female (62%) and white (88%). On average, patients in the home health hospital discharge sample have between one and two additional serious diseases that are not directly related to their hospitalization event (1.45 co-morbidities), are admitted to hospitals 48.5 miles from their home (median distance is 7 miles), and average length of stay—the number of days the patient remains in the hospital—is approximately 6 days.

5% of patient discharges to home health are to home health centers that are co-located with the discharging hospital, where co-location is a dummy that is defined as being equal to one if the two facilities are located within 0.1 miles of one another and zero otherwise. 22% of the patient discharges come from teaching hospitals. Nonprofit hospitals dominate the hospital industry: only 14% of patient discharges are from for-profit hospitals. The average discharge comes from hospitals with 381 beds, though there is substantial variation in hospital size. 31% of discharges go to vertically integrated home health agencies, and 21% of discharges come from the parent hospital of these agencies.[17] 8% of discharges to integrated home health agencies come from non-integrated hospitals. Home health intensity for the home health hospital discharge population is approximately one visit every three days. At the county-level hospital concentration tends to exceed home health concentration with a Herfindahl index of 752 versus 508, respectively, based on patient volumes.

Our main explanatory variable is whether a hospital is vertically integrated into home health (VI_HOSP), a binary variable that is equal to unity if a hospital owns at least one home health agency and zero otherwise. Columns (3) and (4) show the means of the covariates split by observations from non-integrated hospitals and hospitals that are vertically integrated into home health, respectively. One empirical challenge we must face is that integrated hospitals are clearly different from non-integrated hospitals; for example, they are less likely to be for-profit more likely to be government hospitals, and operate less frequently in dense urban areas, but more frequently where hospital and home health concentration is higher, HMO penetration is lower and prevalence of integration into home health amongst other hospitals is higher. As we discuss in more detail below, we deal with this issue by creating a matched sample of patients from vertically integrated and non-integrated hospitals on all observable characteristics, as well as through instrumental variables techniques.

Table 1-B shows summary statistics for patients discharged to skilled nursing facilities. The mean and standard deviation of skilled nursing facility discharges are shown in columns (1) and (2) respectively. Medicare patients discharged to skilled nursing facilities are somewhat older (average age of 81 years), in worse health (1.71 co-morbid conditions), and more female (72%) than Medicare patients discharged to home health. They also stay longer in the hospital before being discharged (about a day longer), and are more likely to be discharged to a co-located facility: 36% of patient discharges to skilled nursing facilities (SNFs) go to SNFs that are co-located with the discharging hospital. SNFs are also less concentrated that home health centers and hospitals, with a Herfindahl index of 229, compared to 744 for hospitals.

The key explanatory variable in empirical tests on skilled nursing facility discharges is vertical integration. For these tests vertical integration (VI_HOSP) is defined by whether the hospital owns its skilled nursing facility. Columns (3) and (4) compare skilled nursing facility discharges from non-vertically integrated and vertically integrated hospitals. As in home health discharges, for-profit hospitals are less likely to be vertically integrated into skilled nursing facilities. However, the difference between the proportion of non- integrated for-profit (13%) and integrated for-profit hospitals (8%) is smaller than in the home health discharge sample. Also, as with home health discharges, vertically integrated hospitals operate in areas where population density and HMO penetration is lower, but SNF concentration is higher.

Our dependent variables index the predictions of our hypotheses: discharges will be faster in vertically integrated hospitals (H1); patients from integrated hospitals will require more intensive monitoring and recovery tasks upon admission to home health (H2); and health outcomes need not be negatively affected by integration (H3). To measure how quickly a hospital discharges their patients, we use a measure of length of stay in the hospital (LOS) that is computed relative to the average length of stay of similar patients in other hospitals by de-meaning from the national average length of stay within each Diagnosis Related Group. The second dependent variable captures the impact of integration on the (downstream) intensity of home health care provision. The intensity of home health care is measured as the number of visits to a patient's home divided by the number of days the patient remains in the care of a home health agency, where visits are weighted by the average wages by occupation of the home health provider as determined from the 2004 Current Population Survey. While most visits are by registered nurses (RN), many visits are by home health aides who are paid considerably less than RNs, while some visits are by specialized therapists who earn more. Our third dependent variable is one of the crucial observable measures of the quality of care patients' receive along the care continuum and the center of policy debates: patient rehospitalization rate.

5. Empirical design

We test the predictions of the model by focusing on how length of stay, home health intensity, and rehospitalization rates (within 60 days of a discharge) vary between patients from non-integrated and hospitals that are vertically integrated into home health care and skilled nursing facilities. Since general tasks—monitoring and recovery activities—are costly to perform in our empirical setting, the model predicts that vertically integrated hospitals will use fiat to force its downstream facilities to accept patients (i) faster and (ii) in poorer health compared to in an arm's length exchange, but that vertically integrated hospitals will manage the cost savings opportunities such that (iii) rehospitalization rates are no greater than in non-integrated settings.

While we are concerned with the endogeneity of vertical integration, we first test these predictions using the simple OLS model (2):

$$(2) \qquad Y_l = a + \beta_1 VI_h + \boldsymbol{X_c \beta_c} + e_i,$$

where l indexes patients, h indexes hospitals, and Y measures three outcomes: length of stay in the hospital *(LOS)*, intensity of care in home health, and rehospitalization rates. VI is an indicator variable that is equal to unity when the hospital is vertically integrated into home health and zero otherwise, $\boldsymbol{X}$ is a vector of patient, hospital, home health agency and market controls that might plausibly shift hospital practice patterns. Patient level controls include variables that capture the health of the patient at admission, measured by 28 comorbidities as well as patients' demographic characteristics, such as age, gender and race. We also include a control for the Euclidian distance between the exact address of the hospital the patient is discharged from and the centroid of the patient's home zip code, as physicians might be expected to keep patients in the hospital longer when they are further from home. Hospital controls include a set of dummies for co-location with the focal type of post-acute care provider (home health center, or skilled nursing facility), ownership (for-profit, not-for-profit, and government), teaching status, and the number of licensed beds. Market controls include hospital, skilled nursing facility, and home health center concentration (Herfindahl) indices, demographic variables such as the average years of schooling of the local population, median income, the percentage of the population over age 65, the percentage of the population of childbearing age (females aged 15-44), population density, and a categorical variable for metropolitan areas; supply shifters including the total number of hospital beds, skilled nursing facility beds, and the number of long-term care beds in the market; and the strength of insurance companies, measured by HMO enrollment rate. Standard errors are clustered at the hospital market level, as defined by the Dartmouth Health Atlas (1999).

Our basic tests are OLS cross-sectional regressions of vertical integration on hospital and home health practice patterns. Although we include a large number of detailed controls, the cross-sectional nature of the analysis precludes us from making strong causal inferences from the OLS results, particularly in tests of the first hypothesis that vertical integration leads to shorter length of stay. Since both vertical integration and length of stay are choice variable for hospitals, our results are vulnerable to selection biases that might lead to heterogeneous treatment effects and omitted variable bias. While it is possible that our OLS estimates could be biased downward due to selection into vertical integration based on (high) organizational quality, it seems more plausible that the OLS estimates of vertical integration on length of stay will be biased toward zero as vertically integrated hospitals tend to be institutions with care management philosophies that emphasize more extensive care delivery over management of financial objectives. For example, non-profit hospitals are sometimes thought to "over deliver" services, at least compared to a for-profit benchmark. We find some evidence for this concern in the raw data. In home health, for-profit hospitals represent 19% of non-integrated hospitals, but only 3% of vertically integrated hospitals. While profit status is observable, the hospital's care management philosophy is not, and we must therefore be concerned that our OLS estimates will confound the causal effect of vertical integration with selection effects.

We deal with the endogeneity of vertical integration using two approaches. First, we adjust for selection on observable differences between patient populations, by matching post-acute care patients from integrated hospitals to patients from non- integrated hospitals, based on all observable characteristics of patients, hospitals and markets. To do so, we use the Coarsened Exact Matching (CEM) procedure described by Iacus, King and Porro (2011), which facilitates multi-dimensional exact matching. CEM is similar to standard two-stage matching techniques in that it controls for selection bias by eliminating non-analogous observations in the treatment (i.e. integrated) and control (i.e., non- integrated) populations. [18] CEM has some advantages over standard matching approaches: it requires fewer ad-hoc post-estimation assumptions about how to define a match; has superior computational properties for large data sets, and is particularly well suited for applications where most regressors are discrete. While CEM is a powerful tool for eliminating the potential that our results are driven by any observable differences in hospitals, markets and the patient population, no matching method can control for sources of heterogeneity that arise from unobservable characteristics of hospitals.

To adjust for selection on unobservables, we exploit variation in local market conditions in the health services industry, using the rate of vertical integration into home health or skilled nursing facilities by other hospitals in the same market (weighted by patient volume) as an instrument for the focal hospital's decision to vertically integrate into home health (VI_HOSP_{-h}). Other hospitals' integration decisions should not have any direct effect on a focal hospital's practice patterns, particularly given the extensive patient, hospital and market controls in specification (1); yet, interviews with industry leaders and experts suggest that hospital integration decisions are often determined by idiosyncratic local market conditions. In particular, we expect that our instrument will pick up the effects of the historical spatial distribution of the local population and local market vertical foreclosure effects, which influence a focal hospital's integration decisions without directly influencing length of stay.

Spatial effects stem from the fact that a patient typically want to have post-acute care delivered close to their home or one of their children's homes. If the local elderly population and their family members tended to live close to, or within an easy commute of, the main urban hospitals in a given area historically, then post-acute care providers also will have tended to locate near the hospitals (whether they are integrated or not). On the one hand, one should expect to see more vertical integration in a market when the at risk population lives near the hospital since the cost of administering a post-acute care center is generally thought to be lower when it is co-located with the hospitals main administrative offices. On the other hand, if a mass of post-acute care providers cluster near urban hospitals it will give hospitals more bargaining power vis-à-vis the post-acute care providers, which will lead to less vertical integration. Thus, the direction of spatial effects on integration depends crucially on the order of entry (which, unfortunately, we do not observe in the data). If independent care providers entered before hospitals vertically integrated we would be more likely to see a decentralized equilibrium, but, if hospitals tended to enter the post-acute care market initially via vertical integration we would be more likely to see an equilibrium where most hospitals were vertically integrated. Regardless of the historical order of entry, our instrument should generate a strong first stage since markets will tend to tip one way or the other. However, given that we control directly for the distance between each patient's home and the hospital they are discharged from in 2005, spatial effects captured by our instrument should only reflect the historical development of the market and should not have any direct effect on a focal hospital's length of stay concurrently.

Similar logic applies to vertical foreclosure effects. If another hospital vertically integrates in a focal hospital's market it reduces the focal hospital's bargaining power because it forecloses a downstream trading partner to the focal hospital. Thus, vertical integration is an idiosyncratic path dependent process that is highly contingent on *other* hospital's characteristics. For example, if a competing hospital in a market has low integration costs or a social mission that emphasizes post-acute care provision they will tend to integrate, which will raise the chances that the focal hospital will integrate. Thus, other hospital's integration decisions influence the focal hospital's integration decision, but other hospital's integration costs should not influence the focal hospital's discharging practices so the instrument should be powerful in the first stage, but should also satisfy the exclusion restriction, particularly because we control for bargaining power directly using hospital, skilled nursing facility, and home health concentration ratios by market.

A practical drawback of our instrumental variable is that it only generates market-level variation. We could not identify any hospital-level shifters of the costs or benefits of diversification that would satisfy the exclusion restriction. However, we find that our instrument generates substantial between-hospital variation in practice, since the 2,571 hospitals in our sample operate in hundreds of different local markets. For the purposes of measuring the instrument, we define the competitive hospital markets based on the 306 Hospital Referral Regions (HRRs) as defined by the Dartmouth Health Atlas (1999).[19] Because the HRRs boundaries are defined based on patient referral patterns for tertiary care, they closely represent the competitive market for hospitals when making decisions regarding vertical integration.

Because our main concern is with the endogeneity of hospital decisions, our key tests of Hypotheses 1 and 3 apply the instrument VI_HOSP_{-h} to correct for selection on unobservables at the hospital-level. Specifically, we use the two-stage residual inclusion (2SRI) method first proposed by Hausman (1978) and more recently by Terza, Basu and Rathouz (2008). The first stage of our 2SRI procedure is a logit model predicting hospital vertical integration into home health or skilled nursing facilities *(VI_HOSP),* including all of the controls in (1) aggregated to the hospital level, where the integration rate of other hospitals in the same market is the source of exogenous variation in each hospital's vertical integration decision. The second stage of the 2SRI procedure includes the residual from the first stage, which by definition is uncorrelated with the covariates in $\boldsymbol{X}$ in (1), and controls for selection into vertical integration based on unobservables. 2SRI estimators have econometric properties that are similar to other two-stage estimators, like two-stage least squares (2SLS), but are particularly well suited for our application. Importantly, they are consistent when endogenous regressors are non-linear and have correct asymptotic standard errors in the first stage, which facilitates a two-stage instrumental variables approach at two different levels of analysis (i.e., hospital and patient) without manually adjusting the standard errors. As a robustness check, we perform a similar analysis, using the more familiar 2SLS estimator, which predicts vertical integration with a first stage linear probability model, replacing the explanatory variable *(VI_HOSP)* in the second stage with the predicted probability of vertical integration into home health. We also verify that our results are robust to matching using CEM prior to 2SRI estimation.

Tests of our second hypothesis—that vertically integrated hospitals will discharge patients to their own (vertically integrated) home health agencies when the patients require more intensive care—compare the outcome resulting from the choice of home health intensity by vertically integrated hospitals with the outcome from market exchanges between non-integrated hospitals and home health agencies, using OLS on the full and matched samples. Ideally, we would want to isolate the causal effect of vertical integration on home health intensity; however, a valid instrument that would generate exogenous variation in the choice of discharge outlet is difficult to identify. Given that endogeneity should bias our results on intensity toward zero due to selection effects—the effect of moral hazard would suggest that hospitals want to keep the healthiest patients for themselves while sending the sickest patients to other agencies—we can test Hypothesis 2 by recovering the cost of the decision to vertically integrate, conditional on the hospital's choice to vertically integrate. Nevertheless, we want to ensure that the treatment and control groups are comparable along all observable dimensions, so that our results are not being driven by unusual observations or model specification issues. To do so, we use CEM as above to match control observations to treatment observations. The impact of hospital vertical integration on practice patterns are then estimated on the matched sample, using OLS model (1).

6. Results

Table 2 Panel A shows the relationship between hospitals vertically integrated into home health and average length of stay at the patient-level. Column 1 reports a -0.12 raw correlation between vertically integration and length of stay, which means that vertical integration is associated with shaving one day off a hospital stay for one out of every eight patients. Including patient controls reduces the correlation to -0.11 (column 2), including patient and hospital controls reduces it further to -0.10 (column 3), while including the full set of patient, hospital and market controls reduces the point estimate to -0.07, and the coefficient estimate becomes indistinguishable from zero (column 4). However, the results in Column 5 demonstrate that patient-level selection effects bias the OLS results toward zero as the coefficient estimate on *VI_HOSP* in the matched sample increases to -0.09. Columns 6-I and 6-II reveal the strength of our instrument and the influence of omitted variable bias on the OLS estimates. Column 6-I is the first stage instrumental variables regression predicting vertical integration at the hospital level. The instrument VI_HOSP_{-h}—other hospitals' rate of vertical integration in the same market (weighted by patient volume)—is very strong: the F-statistic on VI_HOSP_{-h} in the first stage is 63, reflecting the fact that local market characteristics have a strong impact on any individual hospital's decision to vertically integrate, and a 1% increase in the market vertical integration rate leads to a 0.30% increase in a focal hospital's propensity to vertically integrate. The second stage of our instrumental variables approach includes the residual from the first stage to adjust for the effects of unobservable hospital-specific factors that might influence vertical integration decisions. The, result is a point estimate on the coefficient on vertical integration that is twice as large as the OLS estimate at -0.20—approximately a one day reduction in length of stay for every five patients discharged—but continues to be imprecisely estimated.[20] The interpretation of Table 2 Panel A is that there is some, relatively weak, evidence that hospital vertical integration allows hospitals to discharge patients to home health sooner relative to non-integrated hospitals, but any effect would be small—representing savings of only about 3% of bed-days.[21].

Table 2 Panel B shows that the results on length of stay effects for hospital vertically integrated into skilled nursing facilities are larger and more precise compared to vertical integration into home health. Without controls, the correlation between vertical integration and length of stay is -0.27, (column 1), and is precisely estimated. The point estimate is slightly larger at -0.28 when including patient controls (column 2), but falls to -0.27 again when including hospital controls (column 3), and further still to -0.22 when including the full set of patient, hospital and market controls (column 4). Column 5 shows the matched sample estimate. Matching exactly based on all observable characteristics of patients, hospitals, and markets yields a precisely estimated point estimate of -0.20. Finally, columns 6-I and 6-II show the two stages of our instrumental variables analysis. Column 6-I displays marginal effect of other hospitals' integration rate on the focal hospital's probability of vertically integrating, while column 6-II shows the second-stage estimates of integration on length of stay. The interpretation of the coefficient on the instrument is that increasing the extent of vertical integration in a local market by 1% increases the probability that a focal hospital will be vertically integrated by 0.34%. As with home health, the second stage estimate on vertical integration is substantially larger than the OLS estimate. The interpretation of the point estimate of -0.64 on vertical integration is that when hospitals are vertically integrated into skilled nursing facilities they are able to reduce patient length of stay in the hospital by one day for six out of every patients who eventually receive post-acute care at a skilled nursing facility, a reduction in total bed-days of about 9%.[22]

Putting the economic effects in perspective, if the average hospital could shift one hospital bed-day to a skilled nursing facility for six out of every ten patients that go to skilled nursing facilities they could profitably incur up to approximately $100,000 per year of additional administrative costs associated with vertical integration.[23] Of course, establishing break-even points for the average hospital with crude averages can be misleading, particularly because capacity constraints and bureaucratic costs vary across institutions.

Table 3 summarizes the tests of the relationship between integration and the intensity of home health care provided to patients who are admitted to home health.[24] Discharges from vertically integrated hospitals to their own home health agencies ("within firm transition") receive an additional 0.010 visits/day, relative to the baseline rate for patients discharged from non-integrated hospitals, while patients discharged from integrated hospitals to external non-affiliated home health agencies had 0.003 fewer visits per day compared to the baseline (column 1). The F-test on the difference between within firm transitions and external transitions from vertically integrated hospitals is significant at the 1% level, which suggests that within firm transitions are more demanding on the downstream organization relative to market transitions. Controlling for whether external discharges go to other integrated agencies or to non-integrated agencies and for discharges from non-integrated hospitals to vertically integrated agencies with a more refined set of interactions has little effect on the main result. After matching and including the full set of interactions, the point estimate on within firm transitions is 0.012 or 1.2 additional home health visits per 100 day episode. With an average length of a home health episode around 33 days, this suggests that approximately one of every three patients experiencing a within firm transition gets an extra home health visit. Increasing one home health visit for one-third of the 400,000 home health admissions per year that come directly from hospitals would have increased total costs by about \$13 million, assuming the average home health visit costs approximately \$100. Under prospective payment, these costs are borne by the agencies rather than by Medicare.

The higher speed with which integrated hospitals discharge patients and the relatively greater severity of patients' health at admission to their home health agency raises an important public policy question. Are vertically integrated hospitals delivering lower quality care by discharging their patients sicker and quicker? Or do hospitals use integration to increase their efficiency while holding quality of care constant as we predict in our third hypothesis? To answer this question, we test in Table 4 whether health outcomes differ between integrated and non-integrated hospitals for patients discharged to post-acute care by regressing integration on incidence of rehospitalization. We find that in home health the correlation between integration and rehospitalization is indistinguishable from zero in full-sample OLS regressions (column 1), as well as in matched sample (not shown) and 2SRI tests (column 2), suggesting that under integration into home health, patient recovery tasks are shifted downstream without meaningfully affecting quality of care. Put differently, the integrated entity substitutes between inputs along the health care continuum, while staying on the same iso-quality curve.

Column (3) shows that rehospitalization rates for patients discharged to skilled nursing facilities within a vertically integrated system are 0.5% lower compared to patients discharged to skilled nursing facilities from non-integrated hospitals. While the coefficient is precisely estimated, the effect is small economically compared to a baseline rehospitalizaiton rate of approximately 20%. However, after adjusting for the endogeneity of vertical integration using the 2SRI method the point estimate on vertical integration increases to -2.0%. The interpretation is that integration actually leads to improved health outcomes. The results suggest that while integration enables quicker and sicker discharges, the savings obtained are not the result of lowering the quality of care received by patients. Hence, the costs of vertical integration are (presumably) borne administratively.

We close our empirical analysis with two caveats. Although there are substantial unobserved administrative costs associated with vertical integration into home health, our interest, in this paper, is to identify the direct medical costs and benefits of vertical integration while allowing heterogeneous costs of integration, which we proxy for using local market conditions, to generate variation in the data. Our empirical approach relies on interpreting the revealed preferences of hospitals, based on the assumption that hospital organizational decisions are made with efficiency criteria in mind. Though our reveled preference approach is standard in the empirical literature on vertical integration (Joskow 1985, Hortaçsu and Syverson 2007), we caution that we cannot estimate the costs and benefits of vertical integration directly in our analysis. Second, while the unique features of the health services industry make it a particularly appealing context for testing our theory of task allocation, it is reasonable to question the external validity of our findings. We believe that the allocation of tasks to assets is a fundamental determinant of coordination costs whenever the timing of exchange is important, but leave the issue open as an opportunity for future research.

These caveats aside, the results suggest that vertical integration creates economically meaningful opportunities for hospitals to discharge patients earlier and in worse health to home health agencies following hospitalization. We interpret the results as evidence that integration allows firms to solve coordination problems by allocating tasks to assets more efficiently. Our findings do not dispute the idea that vertical integration increases administrative costs, such that, it may be superior to market exchange only for some hospitals (i.e., the ones that choose to become integrated). Nor do we dispute the importance of cascading organizational effects associated with timing problems, as described in the extant literature. Nevertheless, the results point to one of the heretofore underappreciated advantages of vertical integration—control over the allocation of tasks to sites or assets.

7. Conclusion

This paper proposes and tests a theory where integration addresses coordination issues in market exchange by solving task allocation problems. In our framework, we demonstrate how the allocation of general tasks to assets (or sites) influences the efficiency of an economic system by determining the timing of exchange. The model offers a step toward integrating the powerful idea that tradeoffs between discrete structural alternatives define the boundary of the firm in equilibrium, as in transaction cost economics (Williamson 1985), with the intuitively appealing idea that tasks or routines, can also shape firm boundaries by influencing the efficiency of production (Nelson and Winter 1985).

We test the predictions of the model in the context of patient care along the care continuum, from hospitalization to home health agencies and skilled nursing facilities and find a strong relationship between vertical integration and practice patterns. Controlling for the endogeneity of vertical integration, patient characteristics, as well as a host of hospital and market factors, we find hospitals that are vertically integrated tend to discharge patients to their own home health agencies and skilled nursing facilities sooner and in poorer health compared with non-integrated hospitals; yet, health outcomes are actually better for patients who transition to hospitals' own skilled nursing facilities and no worse for patients who transition to hospital's own home health agencies. The variation in practice patterns and health outcomes reflects the integrated entity's ability to use fiat to shift patients in need of recovery and monitoring services (general tasks) from the hospital setting to post-acute care settings. Thus, the evidence suggests that vertical integration reduces coordination problems that arise due to the misallocation of tasks under market exchange.

Our results highlight the unintended consequences of restrictions on gain-sharing across entities. These prohibitions on side-payments and kickbacks, instituted to prevent referrals based on financial interests, contribute to the misallocation of tasks and may create a strong impetus for integration. In this regard, our paper contributes to the ongoing health care reform debate, which focuses on the role of both clinical and financial integration of health care entities in reducing costs and improving the quality of care. The notion that vertically integrated hospitals can successfully sustain quality of care (or even improve it) while increasing efficiency by substituting expensive stays in the hospital with higher post-acute care intensity, speaks directly to the logic behind the concept of Accountable Care Organizations. Our theoretical approach centers around the concept of a focal general task (recovery – in our empirical context), that is misallocated under market exchange. More generally, this calls for further research on the role of the interplay between tasks and assets in defining the boundaries of firms in other settings.

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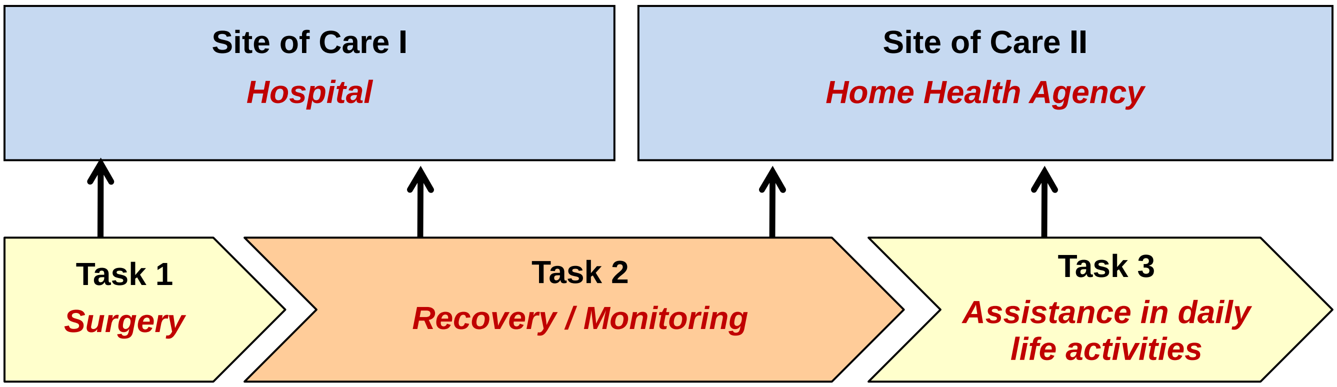
Figure 1
An illustration of asset-dedicated and general tasks along the care continuum.



Notes: surgical interventions, which are hospital-dedicated tasks, are always performed in acute care sites (i.e., hospitals), while assistance in daily home activities, which are post-acute-dedicated tasks, are always performed at the patient's residence or in a nursing home. Recovery/Monitoring, to a large extent, is a general task, which can be performed at the hospital or in a post-acute care setting. Vertical integration gives the firm control over the allocation of this general task.

Figure 2
General tasks and efficient exchange

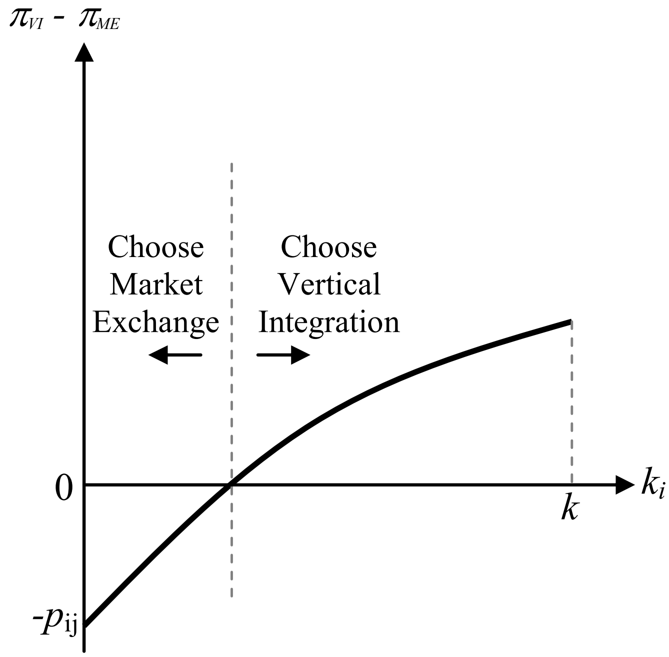


Figure 1 shows the relationship between the size or importance of the general task k_i and the efficiency of exchange (π) under vertical integration (VI) and market exchange (ME), where the cost of performing task k_i and task k_j in the same firm is p_{ij}.

Table 1-A Descriptive statistics for key variables: home health

	Full sample n=399,616		non-VI hosp. n=270,165	VI hosp. N=129,451
	(1)	(2)	(3)	(4)
Patient characteristics	Mean	Stdv	Mean	Mean
Length of stay (days)	5.86	4.96	5.89	5.86
Age (years)	78.1	7.56	78.1	78.2
Male	0.38	0.49	0.38	0.38
White	0.88	0.32	0.87	0.91
Black	0.08	0.27	0.09	0.07
Number of comorbities	1.45	1.18	1.44	1.46
Chronic lung disease	0.20	0.40	0.20	0.21
Diabetes	0.19	0.39	0.19	0.19
Cong. heart failure	0.10	0.30	0.10	0.11
Distance to home from hospital (miles)	18.4	28.5	19.0	17.1
Hospital characteristics				
Vert. integrated into home health (VI HOSP)	0.32	0.47	0.00	1.00
Co-located with a home health center	0.05	0.23	0.02	0.13
Rehospitalization rate	0.17	0.37	0.17	0.17
For-profit	0.14	0.35	0.19	0.03
Government	0.11	0.31	0.09	0.14
Teaching hospital	0.22	0.42	0.23	0.21
Total beds	381	266	382	379
*Home health agency characteristics**				
Home health intensity (visits/day)	0.38	0.21	0.38	0.38
Vertically integrated (VI HHA)	0.31	0.46	0.11	0.72
Within firm transfer (VI HOSP TX)	0.21	0.41	0.00	0.65
VI HOSP to other HHA (VI HOSP EXT)	0.11	0.32	0.00	0.35
VI HOSP to non-VI HHA (VI EXT NON)	0.09	0.29	0.00	0.28
VI HOSP to other VI HHA (VI EXT VI)	0.02	0.15	0.00	0.08
Non-VI HOSP to VI HHA (VI HHA IN)	0.08	0.26	0.11	0.00
Market characteristics (counties)				
Others vert. int. into home health (VI $HOSP_{-h}$)	0.29	0.23	0.25	0.36
Hospital concentration	752	1,288	691	878
SNF concentration	221	423	201	262
Home health concentration	508	675	488	550
% population <9 yr school	7.27	4.41	7.22	7.36
% population college graduates	23.62	9.47	24.43	21.93
Median HH income ($K)	47.25	12.44	48.04	45.62
% population aged 65+	13.52	4.01	13.34	13.89
Metropolitan area dummy	0.80	0.40	0.84	0.72
Population density (pop./square miles)	2,018	6,764	2,407	1,209
Hospital beds	2,588	4,472	2,920	1,898
Long term care hosp. beds	182	406	207	131
Skilled nursing facility beds	3,894	6,566	4,291	3,071
% 15-44 female pop.	20.91	2.24	21.00	20.72
HMO enrollment rate	0.62	0.25	0.65	0.56

*VI_HOSP = VI_HOSP_TX + VI_HOSP_EXT. VI_HOSP_EXT = VI_EXT_NON + VI_EXT_VI. VI_HHA = VI_HHA_OWN + VI_HHA_IN + VI_HHA_TX.

Table 1-B Descriptive statistics for key variables: skilled nursing facility

	Full sample		Non VI hosp.	VI hospitals
	n=460,761		n=294,059	n=166,702
	(1)	(2)	(3)	(4)
	Mean	Stdv	Mean	Mean
Patient characteristics				
Length of stay (days)	6.92	6.15	7.02	6.76
Age (years)	81.47	7.60	81.67	81.14
Male	0.28	0.45	0.28	0.29
White	0.90	0.30	0.90	0.90
Black	0.07	0.26	0.07	0.07
Number of comorbities	1.71	1.21	1.71	1.69
Chronic lung disease	0.19	0.40	0.19	0.20
Diabetes	0.17	0.38	0.17	0.18
Cong. heart failure	0.14	0.35	0.14	0.15
Hypertension	0.14	0.34	0.14	0.14
Distance to home from hospital (miles)	18.3	32.0	18.7	17.6
Hospital characteristics				
Vertically integrated into SNF (VI_HOSP)	0.36	0.48	0.00	1.00
Co-located with a SNF	0.23	0.46	0.26	0.38
Rehospitalization rate	0.20	0.40	0.20	0.19
For-profit	0.12	0.32	0.13	0.08
Government	0.10	0.30	0.10	0.10
Teaching hospital	0.20	0.40	0.21	0.17
Total beds	356	247	355	358
Market characteristics (counties)				
Others vertically integrated (VI_HOSP_{-h})	0.30	0.23	0.28	0.32
Hospital concentration	744	1,279	762	711
SNF concentration	229	461	217	248
Home health concentration	493	658	509	464
% population <9 yr school	6.89	3.88	6.72	7.18
% population college graduates	24.15	9.42	24.93	22.77
Median HH income ($K)	48.20	12.34	49.29	46.28
% population aged 65+	13.40	3.79	13.27	13.64
Metropolitan area dummy	0.81	0.39	0.83	0.76
Population density (pop./square miles)	1,644	5,006	1,862	1,260
Hospital beds	2,539	4,497	2,496	2,615
Long term care hosp. beds	181	382	172	195
Skilled nursing facility beds	3,991	6,748	3,944	4,072
% 15-44 female pop.	20.99	2.12	20.99	20.99
HMO enrollment rate	0.63	0.25	0.65	0.59

Table 2 Vertical integration and length of stay

Dep. var: ΔLOS	(1) OLS		(2) OLS		(3) OLS		(4) OLS		(5) Matched (CEM)		(6-I) 1st stage IV (logit)		(6-II) 2nd stage 2SRI	
Panel A: home health														
Hosp. vertically int. into home health	***-0.12***	**	***-0.11***	**	***-0.10***	*	***-0.07***		***-0.09***	**			***-0.20***	
	(0.05)		***(0.05)***		***(0.05)***		***(0.05)***		***(0.05)***				***(0.15)***	
Other hosp. vert. int. into home health											0.30	***		
											(0.04)			
Residual from 1st stage													0.06	
													(0.06)	
Patient controls	N		Y		Y		Y		Y		Y		Y	
Hospital controls	N		N		Y		Y		Y		Y		Y	
Market controls	N		N		N		Y		Y		Y		Y	
Constant	Y		Y		Y		Y		Y		Y		Y	
R^2/Adj.-R^2/Pseudo-R^2	0.00		0.04		0.04		0.04		0.04		0.16		0.04	
F-test on IV											60			
N	399,616		399,616		399,616		399,616		344,384		2,571		399,616	
Panel B: skilled nursing facility														
Hosp. vertically int. into SNF	***-0.27***	***	***-0.28***	***	***-0.27***	***	***-0.22***	***	***-0.20***	***			***-0.64***	**
	(0.08)		***(0.08)***		***(0.08)***		***(0.06)***		***(0.07)***				***(0.02)***	
Other hosp. vert. int. into home health											0.34	***		
											(0.04)			
Residual from 1st stage													0.20	
													(0.13)	
Patient controls	N		Y		Y		Y		Y		Y		Y	
Hospital controls	N		N		Y		Y		Y		Y		Y	
Market controls	N		N		N		Y		Y		Y		Y	
Constant	Y		Y		Y		Y		Y		Y		Y	
R^2/Adj.-R^2/Pseudo-R^2	0.00		0.05		0.05		0.06		0.06		0.08		0.06	
F-test on IV											72			
N	460,761		460,761		460,761		460,761		397,038		2,571		460,761	

Standard errors are robust and clustered at the market level.*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Patient controls include: age, gender, race, 28 controls for patient health characteristics upon admission to the hospital (Elixhauser comorbidities). Hospital controls include: co-location dummy (with home health or SNF), ownership form dummies {for-profit, government, not-for-profit}, number of beds, and a dummy for teaching hospital. Market controls include: hospital, home health, and SNF concentration; avg. educational attainment, median household income, % of population over 65 year old, a dummy for metropolitan area, population density, number of hospital beds, number of long-term care hospital beds, number of skilled nursing facilities beds, the percentage of women of child bearing age (% of population that is female aged 15-44), and the HMO enrollment rate

Table 3 Vertical integration and intensity of home health care

Dependent variable: home health intensity (visits/day)

	Full sample				Matched sample			
	(1)		(2)		(3)		(4)	
Within firm transfer	***0.010***	**	***0.010***	**	***0.012***	***	***0.012***	***
(VI_HOSP_TX)	***(0.004)***		***(0.004)***		***(0.004)***		***(0.004)***	
VI_HOSP to other HHA	-0.003				-0.001			
(VI_HOSP_EXT)	(0.004)				(0.004)			
VI_HOSP to other VI HHA			-0.004				-0.002	
(VI_EXT_VI)			(0.005)				(0.006)	
VI_HOSP to non-VI_HHA			-0.002				-0.001	
(VI_EXT_NON)			(0.004)				(0.004)	
Non-VI_HOSP to VI_HHA			0.004				0.002	
(VI_HHA_IN)			(0.005)				(0.005)	
Patient controls	Y		Y		Y		Y	
Hospital controls	Y		Y		Y		Y	
Market controls	Y		Y		Y		Y	
Constant	Y		Y		Y		Y	
R^2	0.04		0.04		0.04		0.04	
N	399,368		399,368		342,886		342,886	

Standard errors are robust and clustered at the market level.*** Significant at 1%, ** Significant at 5%, * Significant at 10%
HHA stands for Home Health Agency. Controls are as above (see Table II).

Table 4 Vertical integration and rehospitalization

Dependent variable: rehospitalization rate within 60 days of discharge

	Home health		Skilled nursing facility	
	(1) OLS	(2) 2SRI	(3) OLS	(4) 2SRI
Hosp. vertically integrated	***-0.002***	***0.002***	***-0.005*** **	***-0.020*** **
	(0.002)	***(0.006)***	***(0.002)***	***(0.008)***
Residual from 1st stage		-0.002		0.007 *
		(0.002)		(0.004)
Patient controls	Y	Y	Y	Y
Hospital controls	Y	Y	Y	Y
Market controls	Y	Y	Y	Y
Constant	Y	Y	Y	Y
R^2	0.02	0.02	0.02	0.02
N	399,616	399,616	460,761	460,761

Standard errors are robust and clustered at the market level.*** Significant at 1%, ** Significant at 5%, * Significant at 10%
Controls are as above (see Table II).

Appendix A: Task allocation and economies of scope

Example 1: Economies of scope in tasks

Assume $A_j(k_j, s_j) = k_j \cdot s_j = (k - k_i) \cdot s_j$ and $A_i(s_i, k_i) = s_i \cdot k_i$. The penalty in the case of integration is given by p_{ij}. In addition, assume that the value of assets is the product of the general task, *k*, to the site-dedicated tasks, s_i or s_j.

The payoff from asset A_i is given by $\pi(A_i(s_i, k_i)) = \sqrt{A_i(s_i, k_i)} = \sqrt{s_i \cdot k_i}$ and the payoff from asset A_j is given by $\pi(A_j(k_j, s_j)) = \sqrt{k_j \cdot s_j} = \sqrt{(k - k_i) \cdot s_j}$. The resulting payoff under vertical integration is given by $\pi_{VI} = \sqrt{s_i \cdot k_i} + \sqrt{(k - k_i) \cdot s_j} - p_{ij}$. The optimal pair (k_i^*, k_j^*) is: $k_i^* = \dfrac{s_i \cdot k}{s_i + s_j}, k_j^* = \dfrac{s_j \cdot k}{s_i + s_j}$ (i.e. k_i^* is increasing in s_i and decreasing in s_j).

On the other hand, the payoff under market exchange is given by $\pi_{ME} = \sqrt{s_i \cdot \tilde{k}_i} + \sqrt{(k - \tilde{k}_i) \cdot s_j}$. Note that market exchange leads to the allocation $(\tilde{k}_i, \tilde{k}_j) = (\frac{k}{2}, \frac{k}{2})$.

The difference between payoff under vertical integration, π_{VI}, and under market exchange, π_{ME}, is given by the following equation: $\pi_{VI} - \pi_{ME} = \Delta\pi(k, p_{ij}) = \left[\sqrt{\dfrac{s_i^2 k}{s_i + s_j}} + \sqrt{\dfrac{s_j^2 k}{s_i + s_j}} - p_{ij}\right] - \left[\sqrt{\dfrac{s_i k}{2}} + \sqrt{\dfrac{s_j k}{2}}\right]$, with this difference increasing in the magnitude of the general task, *k*, and decreasing in the cost of vertical integration, p_{ij}:

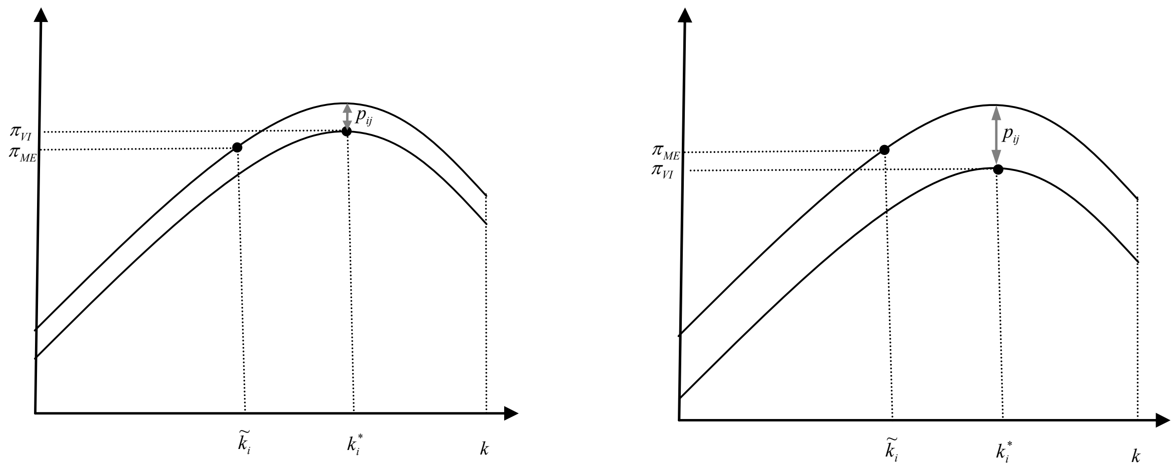
$\dfrac{\partial \Delta\pi(k, p_{ij})}{\partial k} > 0$, and $\dfrac{\partial \Delta\pi(k, p_{ij})}{\partial p_{ij}} < 0$.

The difference between payoff under vertical integration, π_{VI}, and under market exchange, π_{ME}, is given by the following equation: $\pi_{VI} - \pi_{ME} = \Delta\pi(k, p_{ij}) = \left[\sqrt{\dfrac{s_i^2 k}{s_i + s_j}} + \sqrt{\dfrac{s_j^2 k}{s_i + s_j}} - p_{ij}\right] - \left[\sqrt{\dfrac{s_i k}{2}} + \sqrt{\dfrac{s_j k}{2}}\right]$, with this difference increasing in the magnitude of the general task, *k*, and decreasing in the cost of vertical integration, p_{ij}:

$\frac{\partial \Delta \pi(k, p_{ij})}{\partial k} > 0$, and $\frac{\partial \Delta \pi(k, p_{ij})}{\partial p_{ij}} < 0$. Figure A.1 illustrates the tradeoff between vertical integration and market exchange when there are economies of scope in tasks.

Figure A.1 Task allocation and efficient exchange

Firms' choose vertical integration *Firms' choose market exchange*



Example 2: Diseconomies of scope in tasks

In this example, the partials of A_i and A_j satisfy the following conditions: (1) the marginal product of s_i and s_j are strictly positive, and (2) the cross derivatives for (s_i, k_i) and (s_j, k_j) are negative. The following functional form satisfy both conditions: $A_i = s_i - \alpha_i s_i k_i$ and $A_i = s_j - \alpha_j s_j (k - k_j)$. The parameters (α_i, α_j) are meant to capture the intensity of the diseconomies fo scope. As before, the total amount of the general task is fixed and the division of the general task must satisfy $k_i + k_j = k$ (where $k_i, k_j \geq 0$). Furthermore, to ensure that both assets have strictly positive value and that the marginal product of the site-dedicated tasks are also strictly positive, we assume $\alpha_i < 1/k_i$ and $\alpha_j < 1/k_j$. Finally, we assume that the payoff function has the form $\pi(A) = \sqrt{A}$.

The vertically integrated firm solves $max_{k_i} \log(A_i) + \log(A_j) - p_{ij}$.

The first order condition is $\frac{\alpha_i s_i}{s_i - \alpha_i s_i k_i^*} = \frac{\alpha_j s_j}{s_j - \alpha_j k + \alpha_j s_j k_i^*}$. The optimal value of k_i is given by $k_i^* = \frac{k}{2} - \frac{\alpha_i - \alpha_j}{2\alpha_i \alpha_j}$. Note that the general task is divided evenly between the assets if and only if $\alpha_i = \alpha_j$ are equal. Therefore, the allocation of the general task is determined by the relative levels of (α_i, α_j).

Under market exchange, each firm owning only one of the assets prefers to have none of the general task. For example, if a firm owns asset i, $\frac{\partial A_i}{\partial s_i} = 1 - \alpha_i k_i < 0$. The inequality is implied by the assumption: $\alpha_i < 1/k_i$. Since payoffs are increasing in *A*, the firm prefers to avoid doing the general task. A similar task holds for a firm owning the other asset. So, no matter the relative intensities of diseconomies of scope, market exchange will lead to an equal division of the general task across firms and the first-best payoff will not be attained.

The difference between payoffs under vertical integration and market exchange is similar to the expression of the previous example. The difference in payoffs decreases in the value of the penalty function. However, the change in relative payoffs due to changes in the size of the general task depends on the values of (α_i, α_j) and (s_i, s_j).

Example 3: Firms desiring a general task allocation such that, (0,0) < (k_i,k_j) < (1,1)

Assume $A_j(k_j, s_j) = s_j^2 + k_j \cdot s_j - k_j^2 = s_j^2 + (k - k_i) \cdot s_j - (k - k_i)^2$ and $A_i(s_i, k_i) = s_i^2 + s_i \cdot k_i - k_i^2$. The penalty, in the case of integration, is given by p_{ij}. In addition, assume that the value of assets is the product of the general task, *k*, to the site-dedicated tasks, s_i or s_j.

The pair $(\bar{k}_i, \bar{k}_j) = (\frac{s_i}{2}, \frac{s_j}{2})$ represents the desired amount of *k* for each firm/asset. But more importantly, note that as long as $s_i \neq s_j$ → $\bar{k}_i \neq \bar{k}_j$. Note that $\tilde{k}_i = \bar{k}_i - \frac{(\bar{k}_i + \bar{k}_j) - k}{2} = \frac{s_i - s_j}{4} + \frac{k}{2}$ and $\tilde{k}_j = \bar{k}_j - \frac{(\bar{k}_i + \bar{k}_j) - k}{2} = \frac{s_j - s_i}{4} + \frac{k}{2}$.

[1] We focus on Medicare transitions where parties cannot influence the price of exchange and side payments are illegal.

[2] We use the terms assets and sites interchangeably throughout this paper. In health care, as in most service industries, tasks may be performed in multiple physical settings. These settings can be thought of as assets, as traditionally defined in the literature. However, it is perhaps more natural to refer to the location of service provision as a "site."

[3] Technically the definition of temporal specificity provided by Masten, Meehan and Snyder (1991) as "the difficulty of identifying and arranging to have an alternative supplier in place on short notice" (p.9), would not apply in our context, since hospitals almost always have alternative post-acute care providers they can attempt to contract with even on short notice. However, the broader idea that timing problems in market exchange can lead to inefficiencies is clearly germane to this research.

[4] For simplicity we treat the level of k as fixed and discuss inefficiencies that arise from its misallocation across assets. In a less parsimonious model, the level of k could vary as well, such that market exchange leads to under-performance or over-performance of k. This would create an additional source of inefficiency, arising from market exchange, which we do not model here. To ensure that k is carried out in its entirety by one or both firms, we assume $\pi(A(k)) \geq 0$ and $\pi(A(0)) \geq 0$. In other words, a firm will not generate negative surplus when it performs k in its entirety (when it is undesirable) or performs none of it (when it is desirable).

[5] We use "surgery" to include any high intensity specialized post-operative care that can only be delivered in the hospital, such as recovery immediately following surgeries.

[6] Home health care is skilled health care services provided in the home, for a limited duration; most often by registered nurses, rehabilitative therapists, social workers, or home health aides. An episode of home health care is a set of visits over a limited number of weeks in which each visit lasts approximately 1-2 hours.

[7] Skilled nursing facilities (also called long-term care facilities or nursing homes) are establishments that house chronically ill, often elderly patients, and provide post-acute and long-term nursing care. In this study, we focus on the post-acute care function provided by skilled nursing facilities. Post-acute care in nursing homes is covered by Medicare for up to 100 days for beneficiaries who require skilled nursing care services following a hospitalization of at least three consecutive days. (Medicaid may cover continued stays in nursing home for eligible individuals. However, patients may have to deplete their life savings first.) Importantly, for the purposes of this study, skilled nursing facility services are offered by free-standing

and hospital-based facilities. (A freestanding facility is generally part of a nursing home that covers skilled nursing facility services as well as long-term care services.)

[8] It is reasonable to treat health care organizations as if they are profit maximizers for the purposes of understanding whether they will vertically integrate into post-acute care, since even if the provider's objectives deviate from profit maximization, production should not exhibit inefficiencies. On the margin, health care organizations will typically trade off surplus for quantity, quality, or other mission related dimensions, but will not subscribe to a more costly production technology. That is, even if some of the surplus is used to meet other goals, due to multidimensional objectives, such compromise is not achieved through inefficient production (Lakdawalla and Philipson, 2006; Malani et al., 2003).

[9] The risk-adjusted payment is most sensitive to differences in the complexity of care a patient requires, primarily based on the surgical procedure they are recovering from, and is less sensitive to the timing of when a particular patient enters the skilled nursing home. There are occasional exceptions. For example, certain extremely high-cost episodes will receive outlier payments.

[10] There is still some relationship between intensity and reimbursement. Home health episodes can be recertified for additional 60-day episodes. This happens for about 10 percent of home health admissions. The reimbursement for a nursing home stay is fixed per-diem, increasing linearly with length of stay.

[11] From a clinical perspective, a successful transition across levels of care occurs when continuity of care is ensured. We argue that the timing of discharge may have no impact on quality of care as long as quality adjustments on the intensity of care are made by the downstream entity. Although post-acute care providers have some incentive to cut corners on care provision under the current Medicare incentive regime, there are certain institutional safeguards that mitigate this problem to some extent. First, physicians are legally responsible for approving care plans and must see patients once every 30 days during the first 90 days of admission. Second, Medicare also provides some oversight of the quality of medical care and reviews claims for suspicious billing practices. Third, the fixed payment arrangement does provide some incentives to provide quality care because quality care prevents complications that would have to be resolved by the provider without any additional payment. Finally, intrinsic motivation to provide care has consistently been recognized as an incentive for health care providers. (For an extensive discussion of the issues and institutional safeguards please see: Kaiser Family Foundation, "Financial Incentives in the Long-Term Care Context: A First Look at Relevant Information" Publication Nbr 8111, Oct 12, 2010).

[12] Our key predictions are also broadly consistent with an informal health economics literature on vertical integration in hospitals, which notes that patients can be expected to be discharged to post-acute care in poorer health and faster when transitioning to post-acute care within an integrated hospital system since integration eliminates opportunism and solves temporal specificity problems (Robinson 1996, Lehrman and Shore 1998).

[13] Ideally, we would test all three hypotheses developed for patients that transition to either skilled nursing facilities (SNF) or home health agencies. Unfortunately, there is no observable measure of care intensity (to the econometrician) in SNFs, so we confine our analyses in the SNF setting to tests of Hypotheses 1 and 3.

[14] 10% of beneficiaries in Medicare Advantage plans do not have MEDPAR records and are not included in this study.

[15] By following the care of only those patients initiating an episode of care, our sample is less likely to be influenced by unobservable (to the econometrician) practice patterns. For example, hospitals might systematically discharge re-hospitalized patients to home health at a different rate compared to patients who were newly admitted. We also exclude terminally ill patients discharged to hospice or long-term acute-care facilities, patients who die in the hospital, and patients without Medicare Part B coverage, and exclude 8,500 patients because they were in the smallest hospitals (fewer than 10 hospital beds or fewer than 10 discharges in a year to home health and skilled nursing facilities).

[16] We repeat our analyses on a subsample of 202,971 and 207,664 patients discharged to home health and skilled nursing facilities, respectively, following surgery. Our results are robust to excluding patients who received no surgical intervention during their hospital stay.

[17] Typically, discharges from an integrated hospital go to a non-owned home health agency when a patient's home is outside of the hospital's home health service area. Of the 11% of discharges from integrated hospitals that do not go to the hospital's own home health agency, 9% go to non-integrated home health agencies and 2% go to other hospitals' home health agencies.

[18] To manage the "curse of dimensionality," we create a single discrete measure of propensity to vertically integrate, using all secondary controls in (2), which we include in the CEM procedure along with our key controls: age group quartiles, gender, number of comorbidities, diagnostic related group type, hospital bed quartiles, and a metropolitan market dummy.

[19] Although county boundaries offer a less precise market definition, we treat counties as markets for measuring market-level controls as demographic data are more readily available at the county level.

[20] We obtained qualitatively similar results, using 2SLS with first stages at the patient and hospital level.

[21] At an average length of stay of six days, five patients would need 30 bed-days in a non-integrated hospital. In a vertically integrated hospital, the same five patients would require only 29 bed-days. (30-29)/30=3%

[22] At an average length of stay of seven days, ten patients would need 70 bed-days in a non-integrated hospital. In a vertically integrated hospital, the same ten patients would require only 64 bed-days. (70-64)/70=9%

[23] There are approximately 461,000 patients discharged to SNFs each year. If six out of every ten were moved one day early that would result in 276,600 bed-days saved (461,000 x 0.6). The average bed-day reimbursement is $1,121 in a hospital (Candrilli and Mauskopf, 2006), compared to $212 in a SNF (MetLife, 2009), thus the total savings would be $251.4M (276,600 x $929) or $97,832 for each of the 2,570 hospitals in the U.S. Of course, this simple estimate is based on broad averages that do not take fixed costs or capacity constraints into account.

[24] The data for Table III are generated using linked Medicare claims data from the MEDPAR file used in Table II. Although these files are linked, 124 patients (out of 399,368 patients) are without valid home health claims information. These observations are dropped from the home health intensity regressions.